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A new species of *Empoasca* (Hemiptera: Cicadellidae), injurious to citrus in South Africa

by

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A new leafhopper, *Empoasca citrusa*, causing oleocellosis on citrus fruit in South Africa, is described.

Leafhoppers of the genus *Empoasca* Walsh are well-known pests of citrus, causing oleocellosis blemishes on the fruit. According to Ebeling (1959), *E. fabae* (Harris) is mainly responsible for this damage in the U.S.A. and in the past it was usually assumed that the same species is involved in South Africa (Pretorius, 1960). However, according to Ross (1959), *E. fabae* has not yet been recorded from outside continental North America and when leafhopper specimens from various citrus-growing areas in South Africa were studied, it was found that they indeed represent a new species.

Empoasca citrusa spec. nov., figs 1–15

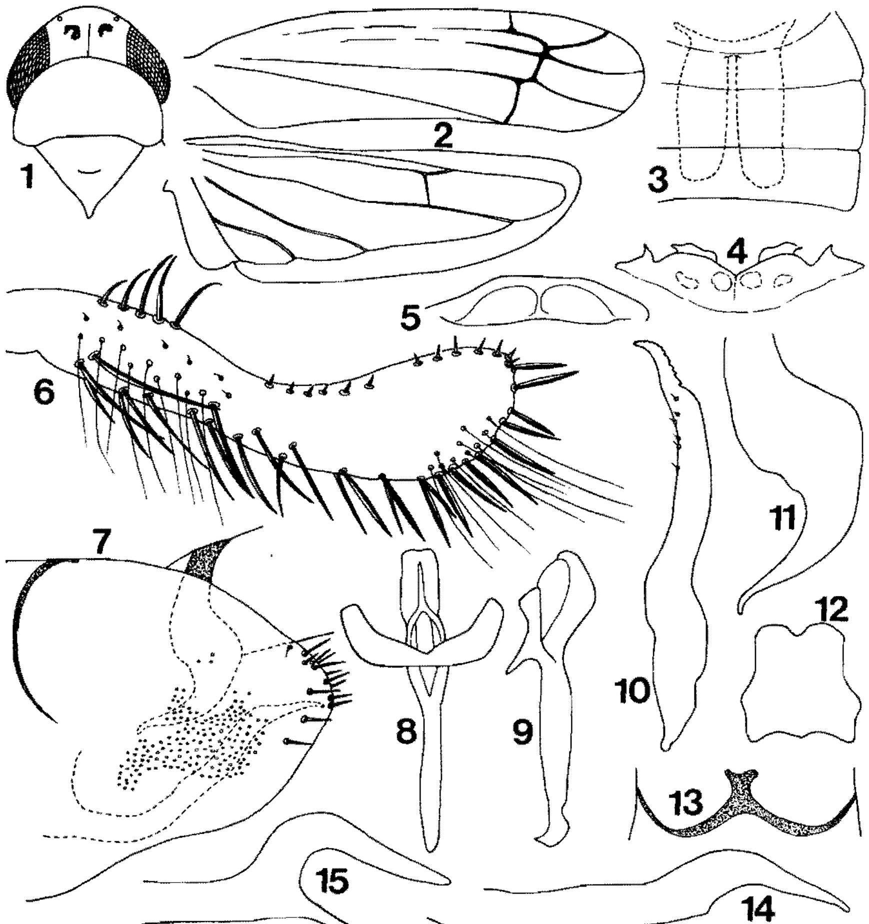
MALE. Length from apex of crown to tips of tegmina 2,9–3,2 mm. General body colour yellowish-green. Head slightly wider than pronotum, width across eyes 0,63–0,7 mm. Crown anteriorly rounded to face, produced medially so that median length is approximately 1,2 times length next eyes and more than $\frac{3}{5}$ median length of pronotum; colour yellowish-green, sometimes with two small bright-green spots (fig. 1), or with paler areas. Each ocellus about equidistant between eye and median line.

Pronotum and scutellum greenish; maximum width of pronotum 0,57–0,7 mm. Tegmina yellowish-green, with only first apical vein arising from cell M (fig. 2); hind wings hyaline. Abdomen yellow; tergal apodemes not developed; phragma of first tergite as in fig. 5; apodemes of first sternite as in fig. 4; apodemes of second sternite more than $2\frac{1}{2}$ segments long (fig. 3).

Anal tube with sharply pointed anteriorly curved hooks (fig. 11). Pygofer dorsally with internal ridge shaped as in fig. 13. Pygofer lobe rounded behind; posteriorly with short setae and laterally with numerous disc pores (fig. 7). Pygofer process (brachone) bent postero-dorsally (fig. 14), with fairly sharply pointed apex directed posteriorly and terminating near hind margin of pygofer lobe; ventral margin usually with longer or shorter spur, which is prolonged into a distinct process in some specimens from Zebediela (fig. 15).

Subgenital plates elongate, extending well beyond hind margin of pygofer and shaped as in fig. 6, with apex in lateral view considerably broader than base; dorsally with a short basal row of 4 or 5 macro-setae, followed by a row of short peg-like setae, which extends to apex; terminally and ventrally with approximately 27 macro-setae and many long thin hairs. Style elongate (fig. 10), with inner edge of laterally-curving apex serrate; distally with short row of micro-setae on outer margin. Connective as in fig. 12.

Aedeagus (figs 8 & 9) with long slender pre-atrium, which distally gives rise to pair of processes, articulating with base of anal tube; apex anteriorly with median flange.



Figs 1–15. *Empoasca citrusa* spec. nov. 1–14, holotype ♂. 1. Head and thorax, dorsal view. 2. Tegmen and hind wing. 3. Apodemes of second abdominal sternite. 4. Apodemes of first abdominal sternite. 5. Phragma of first abdominal tergite. 6. Left plate, lateral view. 7. Pygofer, lateral view. 8, 9. Aedeagus, anterior and lateral views. 10. Right style, dorsal view. 11. Anal hook, lateral view. 12. Connective. 13. Internal dorsal ridge of pygofer. 14. Pygofer process (brachone), lateral view. 15. Terminal part of pygofer process in male from Zebediela.

FEMALE. Length 3,06–3,2 mm; width across eyes 0,68–0,7 mm, maximum width of pronotum 0,66–0,68 mm. 7th abdominal sternite rounded behind.

MATERIAL EXAMINED. ♂-Holotype: SOUTH AFRICA: Citrusdal, C.P., 16.i.1973 (F. Honiball.). In South African Museum, Cape Town. Paratypes: SOUTH AFRICA: 5 ♂♂ and 5 ♀♀, same locality and collector as holotype, 16.i.1973, 9.xii.1968, 2.vi.1966; 7 ♂♂ and 5 ♀♀ Zebediela, Tvl. (A.R.T. Ltd.), 21.iii.1966; 1 ♂ Rosslyn, Tvl., iii.1971 (S. W. Theron); 2 ♂♂ and 2 ♀♀ Addo, C.P., 25.iv.1973 (P. Wahl). In S.A. Museum, Cape Town, University of Stellenbosch Collection and National Collection of Insects, Plant Protection Research Institute, Pretoria.

The specimens studied were collected on navel oranges (Citrusdal), pomelos (Addo) and potatoes (Citrusdal). A parasitized specimen, collected on castor oil plant (Naboomspruit, Tvl.), apparently also belongs to this species.

E. citrusa is closely related to the species named *Kybos theroni* by Gerard (1972), but differs from the latter in the shape of the pygofer process, the greater length of the apodemes of the 2nd abdominal sternite and, to a lesser extent, the shape of the anal hooks. Gerard assigned *theroni* to the genus *Kybos* Fieber, but both *theroni* and *citrusa* show most of the typical characteristics of *Empoasca sensu stricto*, as enumerated by Dlabola (1958), Ross (1963), Le Quesne (1960) and others, i.e. the crown is considerably longer medially than next the eyes and more than half the length of the pronotum, the styles lack the characteristic long setae found in *Kybos* and the two apical veins of the tegmen join the radial cell separately. Two characters, which the above-mentioned species share with *Kybos*, i.e. the fairly large number of macro-setae on the plates and the style with teeth on the convexity of the curved apex, are also found in other species included in *Empoasca*, e.g. *E. pacifica* Vilbaste (1968) and *E. javanica* Dworakowska (1972).

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'Corneus spots' in insects

by

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The occurrence of small chitenous structures, called 'corneus spots', which occur on the membranous parts of some insect wings is briefly surveyed. Only four holometabolous orders possess these structures: Mecoptera, Neuroptera, Trichoptera and Hymenoptera. The detailed external morphology of corneus spots in selected examples from each order has been studied using light and scanning electron microscopy. It is tentatively suggested that corneus spots are either sensory or glandular organs.

INTRODUCTION

Kimmins (1957) and Borror and White (1970) have made use of small 'spots' on the wings of Trichoptera to facilitate identification. These spots have been called 'corneus points', 'facetic spots' or 'wing spots' in literature relating to the Trichoptera (Scott, 1973) and 'chitenous dots' in work on the Mecoptera (Esben-Petersen 1921). These spots have been noticed and illustrated by a number of workers studying the Mecoptera and Neuroptera and these structures, called "Nygmata" or "sensory spots", have been used in a key to Neuropteran families (Riek, 1970). This paper is intended to draw attention to these spots, which will here be referred to as 'corneus spots', and to give (i) an indication as to which insect families possess them, (ii) a description of the spots in representatives of the orders possessing them, and (iii) a few suggestions as to their function.

MATERIALS AND METHODS

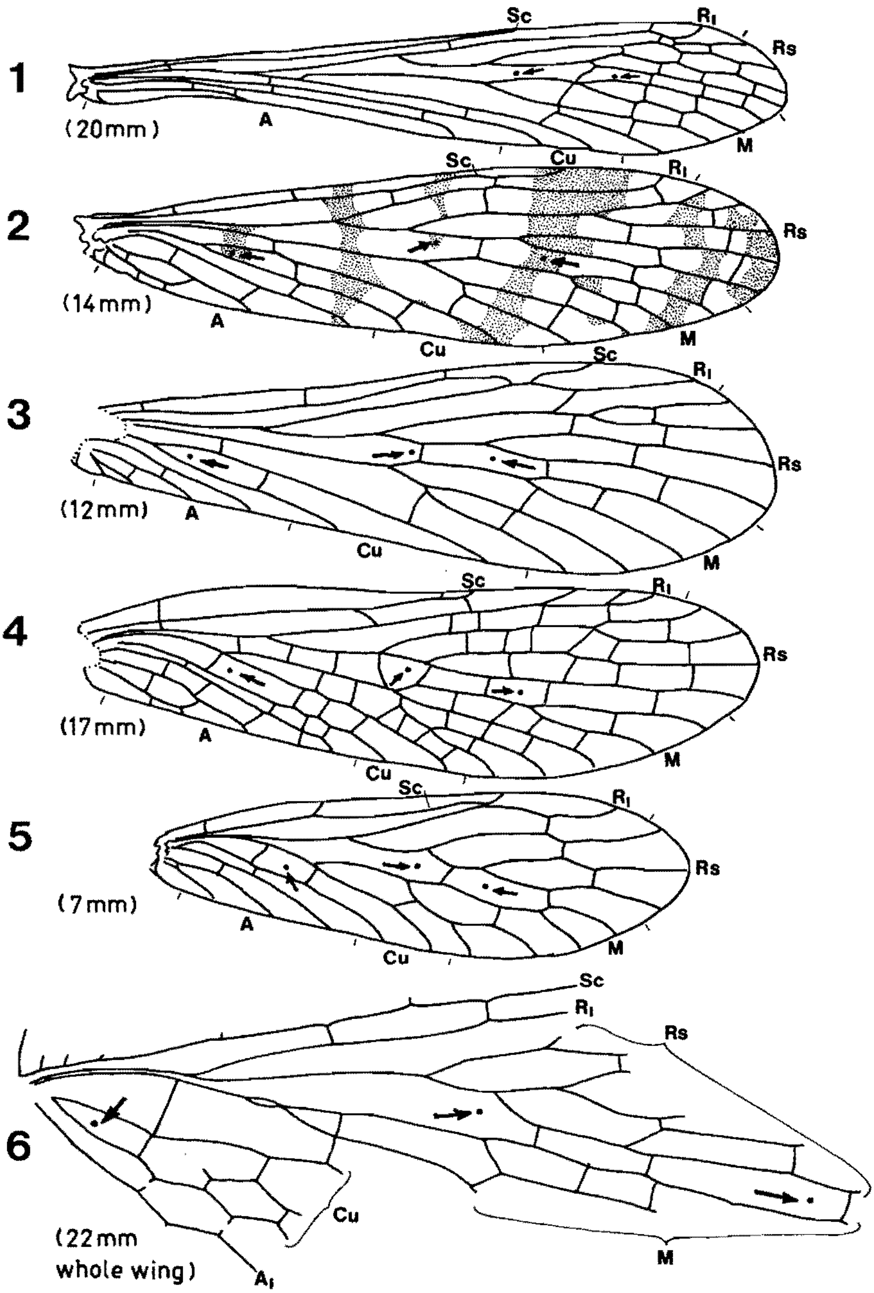
In order to establish which insect families possess corneus spots, representatives of a number of families were studied. The Trichoptera were not studied personally but information pertaining to this group was obtained by studying the excellent illustrations done by Mr D. E. Kimmins in the work of Mosely (1939). The following species were selected for study with a JEOL JSM U3 scanning electron microscope: Mecoptera; *Bittacus smithersi* Londt, *Panorpa latipennis* Hine, *Chorista australis* Klug; Neuroptera; *Taeneochauliodes ochraceopennis* Esben-Petersen; Trichoptera; *Macronema capense* Walker; Hymenoptera; *Athalia himantopus* Klug. Wings were all dry when attached to the specimen stubs by means of 'Sellotape' dissolved in chloroform for scanning electron microscope study. The wings were coated with gold in a Hitachi HUS 3B vacuum evaporator.

OCCURRENCE AND MORPHOLOGY OF CORNEUS SPOTS IN INSECTS

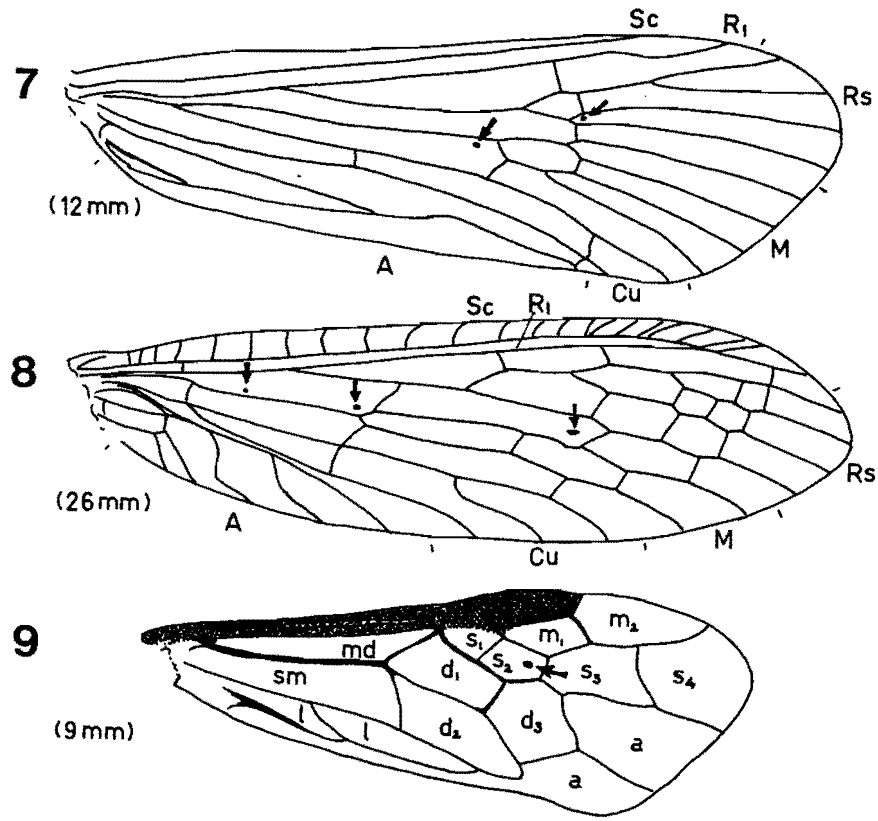
The results of a survey of 122 families belonging to 18 orders of winged insects is presented in Table 1. Only four holometabolous orders possess corneus spots. These are the Mecoptera, Neuroptera, Trichoptera and Hymenoptera.

Table 1. A survey of the number of corneus spots found in the wings of insects. F = fore wing; H = hind wing, — = hind wing absent.

	F	H		F	H		F	H
HEMIMETABOLA			Ithonidae	2	1	Bibionidae	0	—
Ephemeroptera			Hemerobiidae	0	0	Stratiomyidae	0	—
Ephemeridae	0	0	Chrysopidae	0	0	Rhagionidae	0	—
Baetidae	0	0	Psychopsidae	0	0	Tabanidae	0	—
Odonata			,,	1	0	Asilidae	0	—
Lestidae	0	0	Osmylidae	2	2	Nemestrinidae	0	—
Aeshnidae	0	0	**Mecoptera**			Acroceridae	0	—
Gomphidae	0	0	Notiothaumidae	3	3	Therevidae	0	—
Libellulidae	0	0	Choristidae	3	2	Mydaidae	0	—
Plecoptera			Nannochoristidae	3	3	Bombyliidae	0	—
Perlidae	0	0	Panorpidae	3	3	Empididae	0	—
Orthoptera			Panorpodidae	3	3	Syrphidae	0	—
Tettigoniidae	0	0	Bittacidae	2	2	Conopidae	0	—
Gryllidae	0	0	**Lepidoptera**			Diopsidae	0	—
Acrididae	0	0	Papilionidae	0	0	Platystomatidae	0	—
Tridactylidae	0	0	Nymphalidae	0	0	Muscidae	0	—
Mantidae	0	0	Pieridae	0	0	Gasterophilidae	0	—
Blattidae	0	0	Lycaenidae	0	0	Hippoboscidae	0	—
Dermaptera			Saturnidae	0	0	Calliphoridae	0	—
Forficulidae	0	0	Nectuidae	0	0	Tachinidae	0	—
Labiduridae	0	0	Geometridae	0	0	Oestridae	0	—
Embioptera			Sphinidae	0	0	**Hymenoptera**		
Embiidae	0	0	Amatidae	0	0	Argidae	1	0
Isoptera			**Trichoptera**			Tenthredinidae	1	0
Termitidae	0	0	Phryganeidae	2	1	Braconidae	0	0
Psocoptera			Limnophilidae	2	1	Ichneumonidae	0	0
Psocidae	0	0	,,	1	1	Evaniidae	0	0
Homoptera			Sericostomatidae	1	1	Gasteruptionidae	0	0
Cicadidae	0	0	Beraeidae	1	1	Trigonalidae	0	0
Cercopidae	0	0	Molannidae	1	1	Cynipidae	0	0
Cicadellidae	0	0	Odontoceridae	1	1	Chalcididae	0	0
Psyllidae	0	0	Leptoceridae	1	1	Chrysididae	0	0
Aphididae	0	0	Hydropsychidae	2	1	Bethylidae	0	0
Heteroptera			,,	1	1	Scoliidae	0	0
Nepidae	0	0	Polycentropidae	1	1	Mutillidae	0	0
Reduviidae	0	0	,,	2	1	Formicidae	0	0
Pyrrhocoridae	0	0	Psychomyiidae	1	1	Vespidae	0	0
Lygaeidae	0	0	,,	2	1	Sphecidae	0	0
Coreidae	0	0	,,	2	0	Pompilidae	0	0
Pentatomidae	0	0	Philopotamidae	2	1	Halictidae	0	0
Thysanoptera			,,	1	1	Apidae	0	0
Thripidae	0	0	Rhyacophilidae	1	1	**Coleoptera**		
HOLOMETABOLA			,,	1	0	Carabidae	0	0
Neuroptera			Hydroptilidae	0	0	Cicindelidae	0	0
Corydalidae	3–6	2	,,	1	1	Staphylinidae	0	0
Sialidae	0	0	Calanoceratidae	2	1	Coccinelidae	0	0
Coniopterigidae	0	0	**Diptera**			Meloidae	0	0
Mantispidae	0	0	Tipulidae	0	—	Lagriidae	0	0
Nemopteridae	0	0	Psychodidae	0	—	Elateridae	0	0
Myrmeleontidae	0	0	Culicidae	0	—	Buprestidae	0	0
Ascalaphidae	0	0						



Figs 1–6. The positions of corneus spots (indicated by arrows) in the Mecoptera. 1. Bittacidae, *Bittacus smithersi* Londt. 2. Panorpidae, *Panorpa latipennis* Hine. 3. Panorpodidae, *Brachypanorpa carolinensis* (Banks). 4. Choristidae, *Chorista australis* Klug. 5. Nannochoristidae, *Nannochorista holostigma* Tillyard. 6. Notiothaumidae, *Notiothauma reedi* McLachlan, only a small section of the very complicated venation shown. Sc = subcosta; R_1 = first radial; Rs = branches of radial; M = branches of media; Cu = cubitals; A = anals.



Figs 7–9. The positions of corneus spots (indicated by arrows) in the Trichoptera, Neuroptera and Hymenoptera. 7. Trichoptera—Hydropsychidae, *Macronema capense* Walker. 8. Neuroptera—Corydalidae, *Taeneochauliodes ochraceopennis* Esben-Petersen. 9. Hymenoptera—Tenthredinidae, *Athalia himantopus* Klug. Sc = subcosta; R_1 = first radial; Rs = branches of radial; M = branches of media; Cu = cubitals; A = anals; md = median cell; sm = submedian cell; l = lanceolate cell; d_{1-3} = three discoidal cells; s_{1-4} = four submarginal cells; m_{1-2} = two marginal cells; a = apical cell.

MECOPTERA. All the families of winged Mecoptera studied, possess corneus spots. Representatives of the rare family Meropeidae were not available for study. In most families there are three spots in each wing (figs 1–6) and this appears to be the plesiomorphic condition. It is convenient to apply the terms proximal, median and distal to these three spots to facilitate easy reference and comparison. The proximal corneus spot of Mecoptera is found between the first fork of the cubital vein (figs 2–6) and is missing only from the wings of the Bittacidae and the hind wings of the Choristidae. The median and distal spots are located between the radial and media veins and usually occupy the first two cells in the Bittacidae, Panorpidae, Panorpoididae and Nanochoris-

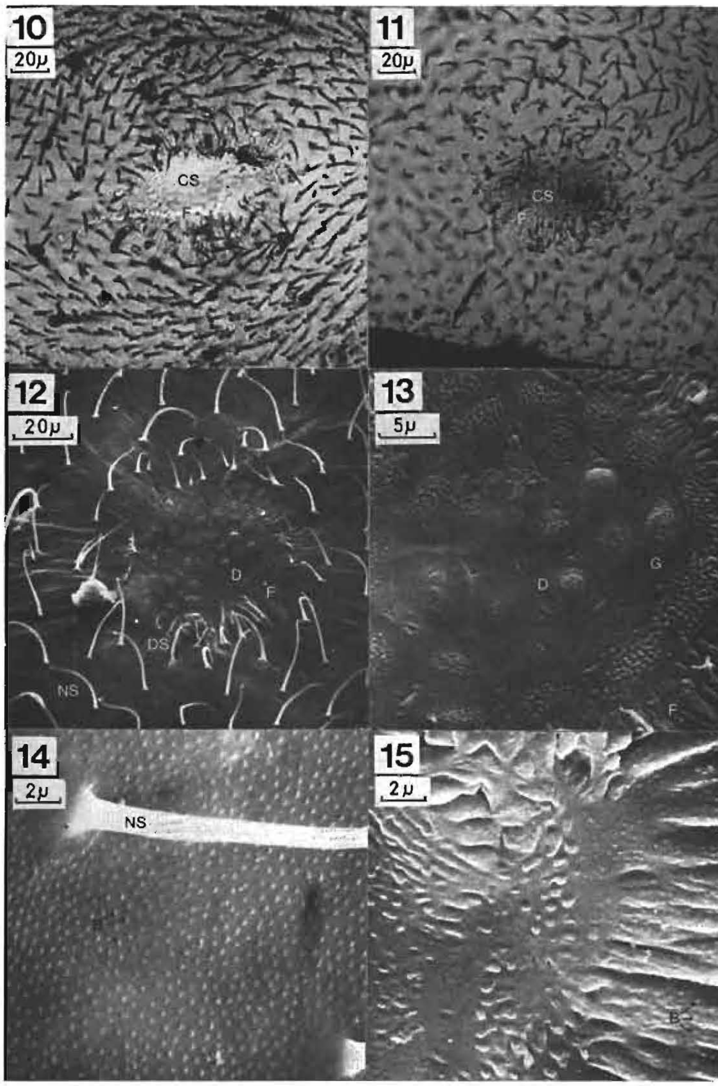
tidae (figs. 1–3, 5), and the first and third cells in the Choristidae and Notiothaumidae (figs 4, 6). In some instances two empty cells may separate these two spots in Notiothaumidae.

The general appearance of corneus spots in the Mecoptera, as seen with a light microscope, is shown in figs 10–11, while surface features seen when using a scanning electron microscope are shown in figs 12–19. The surface of each spot is devoid of setae except at the periphery where small 'degenerate' setae are usually present (figs 12, 16–19). The 'normal' wing setae in the immediate vicinity of each spot appear to be arranged in circular fashion around the spot (figs 10–11). The corneus spots are raised above the surface of the surrounding wing membrane and are surrounded by shallow, radiating, cuticular 'folds' (figs 10–13, 15–19). The surface of each corneus spot may possess small, flattish, circular 'domes' which have a 'lumpy' appearance especially at their apices (figs 12, 13, 16, 18, 19). Each dome may be separated from its neighbours by indistinct shallow grooves (fig. 13). In some examples the surface of the corneus spot is flat and lacks the dome-like structures (fig. 17). It is possible to have both types of spots in the same wing (e.g. Panorpidae, figs 16–17). The surface of corneus spots lack the small regularly spaced 'bumps' (fig. 15) which are evident on the wing membrane surrounding the spots (fig. 14). The appearance of the corneus spot is similar when viewed from upper or lower surface of the wing.

Attempts to section corneus spots for transmission electron microscopy met with little success due chiefly to the difficulties normally encountered when sectioning very thin cuticular structurs. It was, however, established that the corneus spot of *Bittacus peringueyi* Esben-Petersen (Bittacidae), of which fresh material was available, is approximately 1,77 μ thick while the wing membrane surrounding the spot was 0,80 μ thick. It was also evident that the cuticular layer becomes thinner over the corneus spots and that there are small 'ducts' penetrating the cuticle covering the spots. Because of a lack of definition, details of the underlying tissues could not be seen.

TRICHOPTERA. Most families of Trichoptera possess corneus spots. The exception appears to be the family Hydroptilidae where only a few species possess spots. The most usual pattern of occurrence is either one or two spots in the fore wing and a single spot in the hind wing. Where two corneus spots occur it is possible that the proximal 'plesiomorphous' spot has been lost. Where one spot exists both the proximal and median spots may have been eliminated such that the distal one alone is left. There is little variation in position of the corneus spots in the Trichoptera and this variation appears to be the result of fusion or loss of wing veins. When the vein R_5 is present the distal spot lies between R_4 and R_5 (fig. 9) but when R_5 is absent it lies between R_4 and M_1. The median spot usually lies between M_4 and Cu_1. Details of the median corneus spot of *M. capense* are shown in fig. 20. There are a few 'degenerate' setae and deep folds surrounding the spot and the surface of the spot is covered with irregularly shaped 'plates'. The dome-like structures described in the Mecoptera are not present. The distal corneus spot of *M. capense* is very similar in appearance to the median spot but has a smoother surface.

NEUROPTERA. The positions of corneus spots in the Neuroptera are variable. In the Ithonidae and Osmylidae the distal spot lies between the last radial vein and the anterior media vein while the median spot lies between the anterior and posterior media veins. In the Corydalidae all the corneus spots, when present, lie between the radial and media veins (fig. 8) in corresponding positions to the median and distal spots in the



Figs 10–15. Corneus spots in Mecoptera. 10–11. Appearance through light mcroscope. 10. Median corneus spot of *Panorpa latipennis*. 11. Distal spot of *Bittacus smithersi*. 12–15. Scanning electron micrographs. 12. Distal spot of *B. smithersi*, upper surface. 13. Detail of distal spot of *B. smithersi*, upper surface. 14. Detail of general surface of wing membrane of *B. smithersi*. 15. Detail of edge of corneus spot of *B. smithersi*. B = small 'bumps' on wing membrane; CS = corneus spot; D = 'domes'; DS = 'degenerate' setae; F = folded region around spot; G = small grooves separating 'domes'; NS = 'normal' seta on wing membrane.

Mecoptera. In *T. ochraceopennis* more than three corneus spots are sometimes present but the most common number is three. There also appears to be considerable size variation between the spots, the distal one being the largest in all cases (fig. 8). Details of the distal corneus spot in *T. achraceopennis* are shown in fig. 21. No distinct folds surround the spot as in the other examples already described and the setae surrounding the spot are often thicker than 'normal' wing setae and may possess two or three apical points. The surface of the spot is covered with prominant, closely packed 'papillae' each with vertically grooved sides and a rounded apex. The median and proximal spots have a similar appearance but are round in shape and not oblong as is the distal corneus spot.

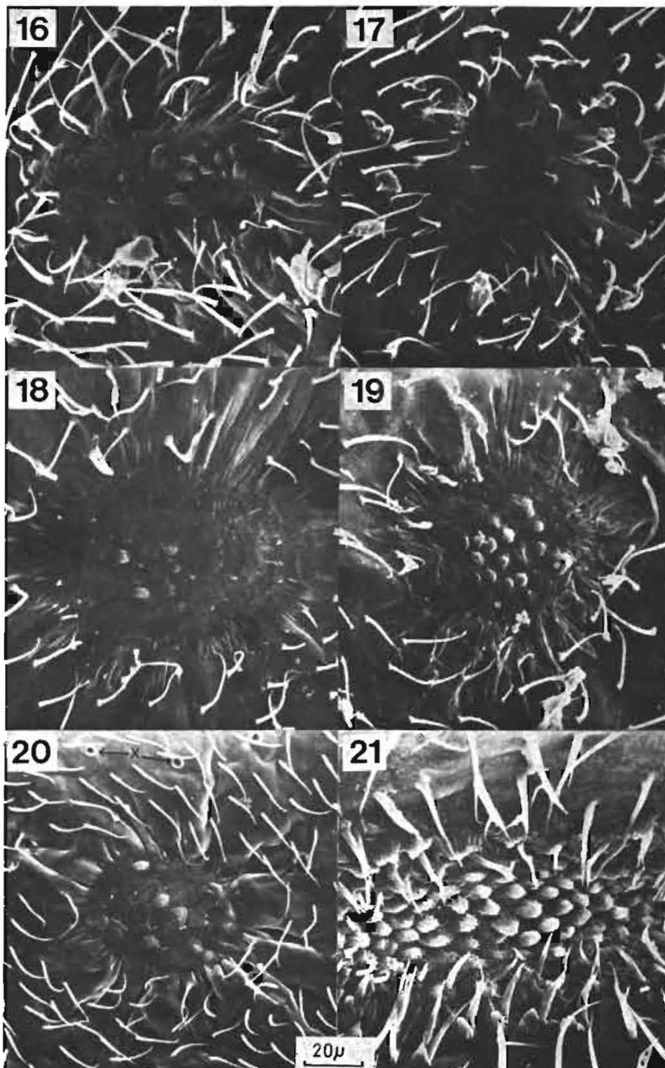
HYMENOPTERA. The only Hymenoptera posessing corneus spots are members of the Symphyta. Both Argidae and Tenthredinidae possess a single corneus spot in the second sub-marginal cell of the fore wing (fig. 9). The corneus spot of *A. himantopus* was studied with the scanning electron microscope and found to be very simple in structure and resembling very closely the distal spot of *P. latipennis* (fig. 17), but the former possesses no 'degenerate' peripheral setae.

DISCUSSION

Although little is known about corneus spots in insects they may prove of interest to workers in a number of different fields of entomological research. Firstly the taxonomist may find the presence, absence, number or positions of corneus spots useful in classification. The fact that corneus spots are present only among members of the 'Panorpoid Complex' may be of interest to phylogeneticists when attempting to draw up the relationships which exist in this interesting complex. Certainly the occurrence of corneus spots in the 'primitive' symphytan Hymenoptera is further evidence that the Hymenoptera were derived from some Mecopteran ancestor as were the Neuroptera and Trichoptera (Sharov 1966). It would be of interest to examine insect fossils for corneus spots. As wings and wing fragments form the bulk of insect fossil material the significance of corneus spots may not at present be fully realised. Studies concerned with the evolution of wing venation may be greatly facilitated by a thorough konwledge of the positions of the corneus spots.

Probably the most interesting studies on corneus spots will be related to their function; as virtually nothing is known of these spots any suggestions pertaining to their function must of necessity be highly speculative. What is certain is that they are not remnants of pupal structures. A pupa of a *Macronema* species studied demonstrated no such structures similar in appearance or position to the corneus spots found in the adult insects.

The structure of corneus spots in the Mecoptera suggest that they may be a group of campaniform sensillae which could have a role in the sensory control of flight. All the insects posessing corneus spots are characterized by being slow and rather feeble flyers. With the evolution of rapid and more efficient flight, as seen in the Diptera and apocrite Hymenoptera, it is possible that corneus spots have been replaced by more superior sensory devices. Two facts which tend to negate the suggestion that these spots are flight monitoring in function are (i) that Zaćwilichowski (1933) has demonstrated the presence of chordotonal sensillae in the wings of Panorpidae and (ii) that corneus spots are thicker than the wing membrane supporting them. Corneus spots are therefore less likely to bend than the wing membrane surrounding them. Campaniform sensillae



Figs 16–21. Scanning electron micrographs of corneus spots in Mecoptera, Trichoptera and Neuroptera. 16. median corneus spot of *Panorpa latipennis*. 17. Distal spot of *P. latipennis*. 18. Proximal spot of *Chorista australis*. 19. Median spot of *C. australis*. 20. Median spot of *Macronema capense*. 21. Distal spot of *Taeneochauliodes ochraceopennis*. X = pits left by dislodged wing setae.

are also usually situated at the wing base which also adds to the evidence suggesting that corneus spots are probably not sensors of wing movements.

Another suggestion as to the function of corneus spots is that they may be chemoreceptors of some type. Certainly the papillae-like structures described in the Corydalidae (fig. 21) resemble basiconic sensillae and is sections of *Bittacus* spots demonstrated small cuticular 'ducts', there seems to be support for this suggestion. A few questions which remain unanswered are (i) why are the 'ducts' not visible in surface view, (ii) why are these organs situated on the wings and not the antennae, (iii) what chemical substances are these organs detecting ?. All insects posessing corneus spots inhabit humid environments or live in association with water. This may suggest that the organs are humidity receptors.

Finally it could be suggested that corneus spots have a secretory function. If glandular, what is the nature and functional significance of the secretion ?. If indeed glandular, the secretions are unlikely to be associated with reproduction as both sexes possess corneus spots and the Bittacidae possess extremely well developed pheromone secreting glands (Bornemissza 1965). Are corneus spots secreting some defensive substance ?. Could they be used in the secreting of cuticular waxes ?. There are many questions which remain unanswered and it is hoped that some of these will receive attention in future studies on insects possessing corneus spots.

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